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CHILTON'S
NOVEMBER 1986

AUTOMOTIVE INDUSTRIES

SINCE 1895

B-O-C Lordstown

B-O-C Lansing South

B-O-C Lansing North

Nissan Smyrna

THE BEST DAMN DIE CHANGE TEAM IN AMERICA

Honda Marysville

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999999 OCT87
JOS MCNALLY COPY #1 S
CONGRESSIONAL INFO SERV CTY
SUITE 800
4520 EAST WEST HWY
BETHESDA MD 20814

NOVEMBER 1986 VOLUME 166, No.11

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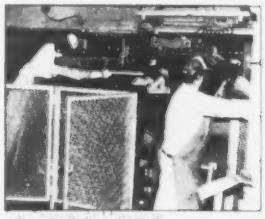

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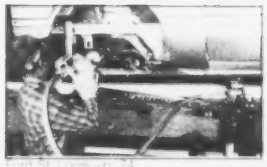

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CERAMICS IN ENGINES? NOT UNTIL PROVEN

Despite performance payoffs, ceramic engine parts still face reliability and cost problems—which are preventing their widespread acceptance.

by Jennifer Minzter

Commercialization of ceramic engine parts in the US may be crawling at a snail's pace, but steadily plodding R&D efforts could push the US industry to the forefront of what experts believe will be a $100 million US market by 1990. By the end of the century that figure could increase to $1.3 billion.

Currently, the Japanese are the only ones firmly pushing ceramic technology towards the production line: Nissan has a silicon nitride turbocharger rotor on its home market 200ZX and Porsche offers cast-in-place aluminum titanate ceramic manifold liners on its 944. Toyota featured a ceramic fiber-reinforced piston in its 2.0 L diesel in 1983.

In addition, Mazda has recently presented an SAE paper describing a prechamber cup in the indirect injection diesel made of silicon nitride. Several other Japanese companies have joined in ventures to quicken the pace of commercialization.

Market forces are providing the Japanese extra incentive: Engine builders pay a hefty tax on engines above 2.0 L. "There's a real strong driving force in Japan to maximize the efficiencies of small engines," explains Chrysler Corp.'s supervisor of Advanced Materials and Technology, John Corwin. "Ceramic parts, chiefly things like turbocharger rotors, go a long way towards helping that."

"In the US," continues Corwin, "there's not the market pull to put ceramic parts in automobiles. I don't think it would make any difference in our cars, as far as our marketability of the product, whether we would say it had a ceramic part in it or not. In Japan there's a certain national marketing hype that tends to give a marketing edge to products that contain ceramic components."

GTE's Buljan helped develop a whisker-reinforced composite ceramic shown here in a molded gas turbine rotor.

US R&D Efforts

That's not to say US ceramic makers are ignoring the potential. R&D, often backed by the Department of Energy and Department of Defense, has produced noteworthy results. Within the next two years, say industry experts, substitution of ceramics for valves and valve train components—turbocharger rotors, exhaust port liners—will occur in limited amount and in the early '90s they'll reach higher volumes.

For instance, Norton/TRW has tested ceramic valve performance in a 2.3 L non-turbocharged diesel engine and after 1000 hours of engine operation, design analyses have shown that the valves can withstand stress, temperatures and corrosive engine environments better than metal valves.

But this limited testing is hardly proof of the pudding. Says Ford's McLean, "These materials are inductile; they don't bend. They're not as tolerant of design inaccuracies as perhaps metals are. Because of that, if things aren't correct in the design, they can fail. The difficulty is that they haven't really been proven for thousands of miles of operation in thousands and thousands of automobiles. Until someone does that, you don't really know what the reliability is."

Assuming that reliability can be proven and development progresses smoothly, by the mid-'90s, engine design will evolve to accommodate ceramic subsystems. An example, says Norton/TRW's technical director of ceramics, Carr Lane Quackenbush, is a cylinder head which would have ceramic guides, seats, exhaust port liners and perhaps, camshaft lobes. "What you'll see is a complete system and then that system will be sold to the OE," says Quackenbush.

It won't be until the mid to late '90s that radical engines—low-heat rejection diesels (adiabatic) and ceramic gas turbine engines will be realized. Note that neither of these two engines is totally ceramic—the ceramic parts will be at key positions within the engines. Reiterates Quackenbush, "We do not envision ever seeing a totally ceramic engine."

At Chrysler's AMT division, Corwin says they are close to introducing valve train components—perhaps a roller cam follower or tappet wear face. "That could very well happen before 1990, at least in small volume," adds Corwin.

Ford is also working on a turbine engine in cooperation with the Garrett Corp., says McLean. The DOE-sponsored program, called the Auto-

motive Gas Turbine (AGT) program, is studying small gas turbines for automotive applications. The Ford/Garrett AGT design is a single shaft with symmetrical components, in which the ceramic components are heavily stressed.

General Motors' Allison Gas Turbine Div.'s DOE-sponsored AGT program is researching a two-shafted, two-rotored design that lessens the stress on the ceramic components involved but complicates the design.

Some ceramic suppliers are increasing ceramic strength and reliability with composite materials. Just announced by GTE Laboratories is the development of a silicon nitride matrix with a silicon carbide whisker composite which, according to the company, is 40% more resistant to internal fracturing and 25% stronger than monolithic ceramics.

The composite development program at GTE is DOE-funded and monitored by the Oak Ridge National Laboratory's three-year-old Ceramic Technology Project. Explains GTE's Tom Buljan, principal researcher on the composite program, the contract involves materials development first, then a low-cost process for manufacturing near-net shape (*see Sept. '86 AI, p. 70*) ceramic parts from pistons to piston liners to rotors.

At Standard Oil (Sohio) Engineered Materials Co.'s $5 million research center in Niagara Falls, NY, development work is centered around ceramic fiber reinforcement of aluminum pistons. For this project, Sohio is using its Fiberfrax, a 49.2% alumina/50.5% silica fiber. The importance of Fiberfrax is its cost: at $1/lb Fiberfrax is cost-efficient for automotive applications. The material is currently being testing for wear and thermal cracking resistance. Other applications include combustion bowls, piston rings and wrist pin areas.

In a program sponsored by the US Army's Tank-Automotive Command (TACOM) to test the friction resistance of silicon carbide and silicon nitride in an adiabatic diesel engine, Sohio is testing a single cylinder engine with two horizontally opposed pistons, using no cooling and no lubrication.

Adiabatic (uncooled) engines pose a major problem, however, and it's one no one yet knows how to solve. As the engine is increasingly insulated, the temperature of the ceramic components goes higher and higher, the NOx emissions shoot up and the oil starts to cook. "At a temperature above 600°C," says Quackenbush, "people have come to a loss as to how to liquid lubricate them."

Ceramic Parts In Production

Ceramic Part	Car Maker	Ceramic Maker	Intro Date	1986 Usage
Diesel Glow Plug	Isuzu	Kyocera	1981	400,000
	Mitsubishi	Kyocera	1983	
	Toyota	Toyota	1984	
	Caterpillar	Kyocera	1986	
Pre-Combustion Chamber	Isuzu	Kyocera	1981	15,000
	Mazda		1986	
	Toyota		1986	
Exhaust Port Liner	Porsche	Hoechst		
Rocker Arm Pad	Mitsubishi		1984	
Turbo Rotor	Nissan	NTK	1985	500/mo.

The Tribo Needs

In Japan Hino Motors Ltd. has just announced the development of a high-performance ceramic compound turbocharged diesel engine for heavy-duty trucks. About 40% of this engine's cylinders, pistons and other combustion chamber parts are ceramic—those parts demanding heat and wear resistivity. Other parts are primarily made of cast iron. According to Hino, horsepower has been boosted 10%, while fuel costs dropped 30%. Part of this engine's innovative design is its unique exhaust gas recovery system which uses an electronically-controlled CVT system to keep exhaust gas recovery efficiency at maximum levels regardless of speed and load.

Hino says its research shows that keeping the ceramics usage at about 40% of engine parts is optimal.

Here in the US Cummins Engine Co. is working with the DOE and US Army on an uncooled engine using zirconia to insulate the cylinders and pistons. The heat in the combustion chamber and exhaust is used to power a turbocharger for increased power.

While R&D may be the moving force behind ceramic development, cost is still applying the brakes to commercialization. Chrysler's Corwin, who maintains US suppliers are much farther ahead of the Japanese in the area of tribology—wear and friction resistance—says that although the Japanese are getting the job done, they are not cost-conscious like US suppliers.

"There are certain ceramics—more expensive ones silicon nitride, silicon carbide," explains Corwin, "that tribologically are very good materials. But they're very expensive materials. What we're trying to do is satisfy all the tribo needs with a much, much less costly material. We're getting into oxide ceramic systems.

"Our goal is to get cost competitive with the metal parts," he says. "In general we're not willing to pay a premium price for ceramic parts that are substitutional for metal parts even though they may have a slightly better projected life, and maybe slightly better performance.

Corwin explains that the "who's ahead" philosophy is a major difference between the current US and Japanese approaches to ceramics use. "I think some of the Japanese companies put ceramic parts in their automobiles, even at a terrific cost penalty, just so they can get the market advantage of saying they have it," he says.

So the question remains: Can automakers and ceramics makers meet the performance, reliability and cost criteria of ceramics? AI

AUTOMAKER QUARTERLY REPORT

Third quarter '86 results show Ford in the passing lane, Chrysler and Honda with a drop in earnings and continued strength at Subaru.

by Tom O'Grady

Domestic Auto Sales (3rd Quarter Results)

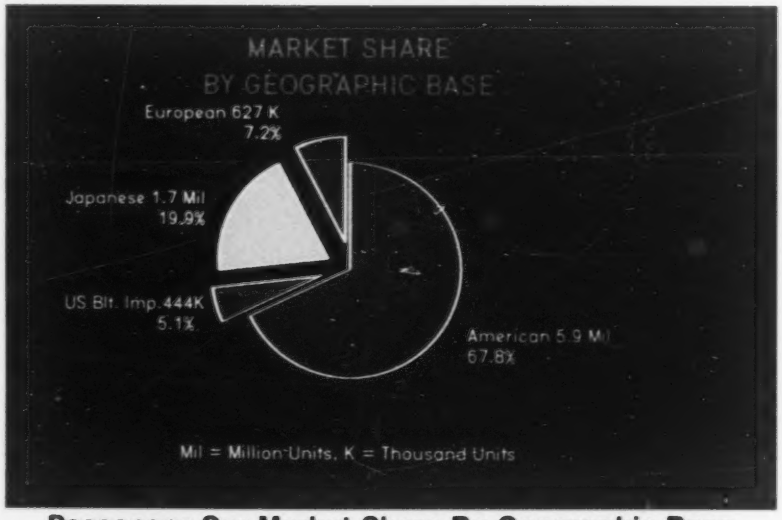
Carline	'86	'85	% Change
Escort	113,906	116,359	(2%)
Celebrity	100,327	104,270	(4%)
Olds 88	97,515	49,501	49%
Ciera	92,816	91,845	1%
Cavalier	90,187	109,627	(22%)
Accord*	81,428	49,274	39%
Tempo	74,106	74,350	0%
Nova	76,504	13,127	83%
Century	67,773	68,404	(1%)
6000	65,932	48,366	27%

*—Includes imports
( )—Negative value

'86 Domestic Light Truck Quarterly Production

Truckline	1-'86	2-'86	3-'86
Chrysler Vans	35,643	29,344	19,651
. Sport Utility	6,407	6,663	6,441
....Miniwagon	75,881	77,051	56,811
Lt Conventional	5,660	34,370	48,812
Ford Aerostar	48,654	45,827	41,142
.....Bronco	13,373	15,407	10,322
..... Econoline	61,782	62,902	45,957
..... Ranger	81,879	86,950	73,124
..... Bronco II	34,147	31,862	25,081
..... Light Conv.	109,848	177,432	146,735
Chevy..Blazer	9,802	7,834	6,352
.....Suburban	17,766	17,450	13,582
..... P-Model	9,898	13,141	7,608

Truckline	1-'86	2-'86	3-'86
.....S-10	64,080	61,889	66,846
.....Blazer S	48,460	42,389	42,977
.....Astro	39,317	42,127	39,270
..... Van	50,348	43,383	27,386
Light Conventional	120,943	114,224	89,385
GMC . Jimmy	2,394	2,179	2,263
.... Suburban	6,000	6,398	5,989
..... P-Model	1,659	1,508	1,135
.....S-15	16,952	16,834	16,646
..... Jimmy S	12,588	11,539	12,053
..... Safari	9,314	10,394	9,632
..... Van	14,487	14,956	8,069
Light Conventional	40,225	39,658	30,213
Nissan. Pkup	18,463	46,222	23,135



Passenger Car Market Share By Geographic Base

Manufacturers	Total Sales	Total Market Share
American	5,942,605	67.84%
Japanese	1,743,901	19.91%
European	627,555	7.16%
US Built Imports (VWoA, Honda, NUMMI, Nissan, Renault)	444,920	5.08%
Total	8,758,981	100.00%

US Passenger Car Market Shares To Date

Manufacturer	Sales	% Total
General Motors	3,751,578	42.85%
Ford	1,569,975	17.93%
Chrysler	1,010,887	11.55%
Honda	475,528	5.43%
Toyota	448,524	5.12%
Nissan	414,279	4.73%
VW	161,679	1.85%
Subaru	137,283	1.57%
AMC/Renault	61,255	0.70%

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